# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS

PRE-EXPENDED BIN MATERIAL MANAGEMENT
AT
NAVAL AIR REWORK FACILITIES

BY

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June 1980

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Pre-Expended Bin Material Management at Naval Air Rework Facilities | | 5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; June 1980 |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) J. E. Vogelsang | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 12. REPORT DATE June 1980 |
| | | 13. NUMBER OF PAGES 73 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California 93940 | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Inventory Control
Naval Air Rework Facilities
Production
Pre-Expended Bin
Industrial Support Material
Spare Parts

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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# Pre-Expended Bin Material Management
# at
# Naval Air Rework Facilities

by

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Submitted in partial fulfillment of the
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MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
JUNE 1980

# ABSTRACT

Naval Air Rework Facilities (NARFs) are the major industrial component of the Naval Air Systems Command. In the accomplishment of their industrial mission, the NARFs require an extensive range of material to support their various production programs. Low cost, high usage material is managed by a concept known as Pre-Expended Bin (PEB). The PEB material typically receives little management attention and has been the source of criticism from periodic material management audits. Auditors have estimated the value of PEB inventories to be about one million dollars per NARF. This thesis proposes a system to improve PEB management by formalizing the decision rules and providing a method of gathering required demand data. The thesis is concluded with a discussion of some of the implementation considerations of the proposed system.

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# I. INTRODUCTION

A list of reasons for holding inventories is found in almost every textbook containing information on the subject of inventory management. One of the most important reasons cited is the decoupling nature of inventories. When material is held in inventory, it allows a certain amount of independence between various steps of a production process that would not otherwise be possible. As a simple analogy, imagine how difficult it would be to prepare meals at home if no stocks of food were maintained there, and all food had to be purchased before each meal.

This paper will address the production support inventory maintained at Naval Air Rework Facilities (NARFs) known as Pre-Expended Bin (PEB) material. This material is recognized to be only a very small portion of the overall NARF operation and is very low on the priority list of items demanding management attention. However, it is believed that this increases rather than decreases the value of this discussion because this is an area that typically receives very little management attention.

Background information concerning the NARFs, the supply system that supports them, and the value of inventories will be given. A survey of NARF inventory management practices will follow the background information. And finally, a proposed system for management of PEB material as well as comments on the practical implementation issues of the proposed system will be presented.

# II. BACKGROUND

## A. NAVAL AIR REWORK FACILITIES

The major industrial component of the Naval Air Systems Command consists of the six Naval Air Rework Facilities (NARFs) located at: North Island, California; Alameda, California; Norfolk, Virginia; Pensacola, Florida; Jacksonville, Florida; and Cherry Point, North Carolina. These six NARFs employ approximately 25,000 persons and provide an extensive range of organic rework and repair capability. (Ref: 1)

The major production programs at the NARFs are typically aircraft, missile, engine, component, and other support programs. The aircraft and missile programs include overhaul/repair on weapons systems (such as the A-6 aircraft or Sparrow missile) and major programs such as the F-4 Service Life Extension Program (SLEP). The engine programs include repair and regularly scheduled maintenance on engines that have been removed from aircraft. The component programs such as B08, CLAMP, and HI-BURNER are for repair of components that have been removed at an operating site and returned to the NARF for repair. Upon completion of repair, these items will be returned to the inventory of ready-for-issue (RFI) assets available to fulfill future needs.

## B. NARF SUPPLY SUPPORT SYSTEM

NARF material supply support is provided by the Navy Supply System. A clear picture of this system is somewhat difficult to

present due to descriptive terms such as wholesale, intermediate, and consumer level stocks which are not clearly defined. The supply system is organized around logistical support requirements and, as a consequence, some activities manage more than one classification of material and in some cases the same material seems to have more than one classification.

In general terms, the wholesale category applies to material that is controlled by a centralized Inventory Manager (IM) through Transaction Item Reporting (TIR) procedures. The inventory manager is normally located at one of the major Inventory Control Points (ICP) or Hardware Systems Commands (HSC), while the material is physically stocked at a major stock point. A major stock point is an activity such as a Naval Supply Center or Naval Air Station. However, part of the definition difficulty for wholesale stock results from the positioning policy. Since some items are stocked at Naval Air Stations and Naval Shipyards where the material is also used, the term "wholesale" seems somewhat imprecise.

The intermediate level is defined by default as "any level of stock positioned between wholesale and consumer levels...." (Ref:2) This includes the "Retail" system which is material centrally managed at the wholesale level by the Defense Logistics Agency (DLA), General Services Administration (GSA), or other services, but is funded by the Navy Stock Fund and pre-positioned at a Navy stock point. At the retail level this material is controlled by Navy inventory policy. The intermediate level also includes the material carried onboard the Mobile Logistics

Support Forces (MLSF) in support of operating units. Additionally, material carried in Shop Stores, Ready Supply Stores, and Servmarts is considered as intermediate level material.

The consumer level of inventory includes the shipboard stock carried in non-MLSF ships and ashore inventories for organic support of operating activities not responsible for supply support of other activities.

NARFs appear to be directly supported by all three levels. Much of the material used by NARFs is carried by the Navy supply system as wholesale stocks and is positioned at supply centers and air stations. This is true for intermediate level "retail" stock as well.

At the consumer level, the NARF has material carried under several different stocking policies. Direct Material Inventory (DMI) is material ordered for specific jobs and held in temporary storage awaiting the start of that job. Customer Furnished Material (CFM) is similar to DMI in its identification for use on a specific job; the difference is that the CFM is procured by the customer and provided to the NARF.

NARFs also carry material termed as Material and Supplies Inventory. At the time of procurement this material is not identified to a specific job but rather is stocked for anticipated future requirements or is stocked as insurance to protect against production line shutdowns. This material is further classified as either Navy Industrial Fund (NIF) Stores or Pre-Expended Bin (PEB) Material depending on the method of

storage, issue, and accounting procedures.

From the preceding discussion it can be seen that the supply system that supports the NARFs is indeed complex. One reason for this is the scope of the work performed by the NARF. Although they may be external to the NARF environment, there are a number of other factors that contribute to the complexity of the supply system and impact on its support of the NARFs.

## C. THE VALUE OF INVENTORIES

Among the many things requiring the attention of inventory managers are the inevitable periodic audits and inspections designed to evaluate how well material is being managed. Since excess inventories are so often cited as a common and recurring problem, it is possible to conclude that inventories are something that should be minimized. This is not a valid conclusion. Inventories serve an important function. Organizations that carry minimal inventory levels can incur extremely high production and distribution costs. (Ref: 3) This is, in fact, the basic principle underlying "modern" or "scientific" inventory management, which has the goal of devising a method for determining optimal inventory policies for the given situation.

It should be noted that quite often an accurate description of the situation is the most difficult step in this process and is the source of much controversy. The exact nature of the costs resulting from positioning, having, or not having an item in inventory can be very difficult to obtain and justify. However,

from a conceptual viewpoint, the problem seems reasonably clear. The costs associated with an inventory system can be grouped into three categories:

1. Procurement Costs
2. Holding (or carrying) Costs
3. Stockout Costs

Further, in the classification of costs, it is a generally accepted principle that only variable costs are considered in the analysis of the depth of inventories. The fixed costs have no impact on the final decision and can be ignored to simplify the process.

Procurement costs are the costs incurred as a result of the ordering process. These include such items as determining that an order is necessary, placing the order, processing the receipt, storing the material, and documenting the above actions. Procurement costs can be reduced by making relatively large, infrequent orders.

Costs associated with the existence of inventories are commonly referred to as holding costs. In general, these costs include elements such as as storage and handling, taxes, insurance, spoilage, obsolescence, pilferage, and opportunity costs. These costs can indeed be very difficult to accurately quantify and are usually simplified by assuming they exhibit a linear relationship to inventory investment levels. (Ref: 4) They can then be expressed in terms of cost per year per dollar of average inventory investment. Holding costs can be reduced by keeping order quantities small and, hence, work in direct

opposition to procurement costs.

Stockout costs are incurred when material is needed but is not immediately available. These costs, like the procurement costs, require relatively large infrequent orders for minimization. The quantification of these costs has long been a difficult question that is sometimes impossible to answer. As a result, two separate approaches have been developed to address the issue of stockout costs in inventory models. One method is to explicitly cost out the shortages and then minimize the total relevant costs. If it is too difficult to assign a value to stockout costs, another approach is to specify a desired service level. (Ref: 5) This desired service level has imbedded in it some implied shortage cost and is used as a constraint in the model.

Superimposed over the cost structure is a set of constraints that place real limits on what can be attained. Typical constraints include such things as the ever-present budget limit, workload capacity, space limitations, minimum order requirements, or required service level. The problem to be solved is then to determine when and how much to order to maintain a balance between ordering, holding, and shortage costs while not violating any of the constraints.

## D. SHORTAGES AT THE NARF

From the viewpoint of the NARF, material supply is a key element in the production process. If material is not available at required times, plans and schedules become worthless and the

cost of operations increases rapidly. Material shortages affect the NARF production by creating production inefficiencies and delays, thereby reducing the output into the distribution channel. The end result of this is an overall increase in the cost of operations. Unfortunately, a recent attempt to evaluate the effect of shortages at NARF Alameda concluded that information required to assign a monetary value to shortage costs was not available in the current data base. (Ref: 6)

## E. NAVY INVENTORY MANAGEMENT

The determination of the "correct amount" to order or the depth of stock of an item is not a trivial problem. This has been and will surely continue to be one of the most challenging problems faced by the Navy Supply System. There are different systems and methods employed at the different levels that try to resolve this question.

The majority of the centrally managed wholesale material is managed by the Uniform Inventory Control Program (UICP) at the Ships Parts Control Center (SPCC) and the Aviation Supply Office (ASO), which are the two major Inventory Control Points (ICP). There is a smaller portion of this type of material that is managed by the Hardware Systems Commands (HSC) which, in general, use manual procedures with more personal attention to each item. The intermediate level material is managed by the Uniform Automated Data Processing System-Stock Point (UADPS-SP) or the Shipboard Uniform Automated Data Processing System (SUADPS), depending on where the material is stocked.

The UICP, UADPS-SP, and SUADPS models are relatively complex inventory models designed for general inventory management of a large number of line items in support of the Naval establishment and are designed to implement the policy of the Naval Supply Systems Command (NAVSUP). They are all subject to the control of the Fleet Material Support Office (FMSO) which is the central design agency.

## F. DEMAND FORECASTING

An important part of inventory control is some form of forecasting technique to predict future requirements. This is due to the fact that decisions need to be made in the present to provide support for future operations. The Navy systems mentioned above are all based on the projection of historical demand to forecast future requirements. The assumption is made that each item is independent of all the other items and will continue to exhibit past demand patterns in the future. This may not always be an appropriate assumption.

In a manufacturing environment, basically the only item with independent demand is the final product. Once the final product quantity is determined (by whatever method) the requirements for all the individual subcomponents that make up the final product can be determined by their relationship to the finished product. While this concept sounds quite simple, the actual implementation of it is usually complex. This is due to the amount of detailed information necessary to accurately translate the final product demand down to the subcomponent level, to keep this information

current based on engineering changes, and to continually evaluate the effects of production schedule changes over time to keep the inventory support system functioning correctly. This concept, known as Material Requirements Planning (MRP), has grown in popularity in recent years. If sufficient information processing capability is available, it has significant advantages for manufacturing environments. (Ref: 7)

Although NARFs are production facilities, the nature of NARF overhaul/repair programs presents a material support problem that is somewhat different from a manufacturing activity. In an overhaul/repair environment such as at the NARF, application of MRP becomes more complex because the subcomponents needed are not strictly determined by the final or end products. The extent of each repair is different and the resulting material needs can become a stochastic event instead of being exactly determined by the production schedule. Obviously, however, the subcomponent demands are not totally independent of the end item repair schedule. Therefore a system that incorporates schedule data into its forecasting function has definite appeal over strictly random demand forecasting systems.

Currently at NARF Alameda a system is being designed and tested that uses a modified form of Material Requirements Planning as a basis for requirements determination for the Operational Support Inventory established at the Naval Supply Center Oakland. The implementation plan is organized into two phases: (Ref: 8)

"I. Implementation of a temporary system that will run on existing equipment and will be used to gain experience with the system and build up the necessary data files. This phase will include the design of the target system.

II. Implementation of the final system on the new computerized material handling equipment -- namely, NISTARS/ASKARS (Naval Integrated Storage and Retrieval System/ Automated Storage, Kitting and Retrieval System)."

As noted before, the practical implementation of this type of concept is quite difficult due to the level of detail required. As a consequence, the complete implementation of this plan will likely take several years. If it is successful, the incorporation of accurate planned production information into the forecasting of inventory requirements will surely have to be classified as a major progressive step. After it becomes operational, it should be expanded to other areas, possibly including the determination of PEB material. However, for the remainder of this paper, the assumption will be that the MRP system is still in the test phase and is not available for use in managing PEB material.

## III. CURRENT NARF INVENTORY MANAGEMENT

### A. POLICY GUIDANCE

The material inventory policies considered for the rest of this paper will be limited to the Material and Supplies Inventories (ie, NIF Stores and PEB Material). The NAVCOMPT Manual (Ref: 9) paragraph 038185 specifies the policy for material inventory control for industrial funded inventories. The policy is specified to be the same as for shop stores as prescribed in the NAVSUP Manual (Ref: 10) paragraphs 25600 thru 25616. The NAVSUP Manual states:

> "The stock of each item in shop stores will not exceed a quantity estimated to be needed for a three month period, based on the average of the preceding four quarters of usage data, subject to the requirements that stock be replenished in full package quantities. However, for insurance items and for new items which usage data has not been accumulated, such stock levels do not apply. The stock levels of insurance items will be limited to the quantity it is anticipated will be required to satisfy the emergency or circumstance for which the item is held.... Insurance items will be reviewed annually... to reduce to a minimum the stock of such items...."

In addition to the above procedures for shop stores, additional policy is specified for Pre-Expended Bin (PEB) material:

"...pre-expended items will not duplicate items stocked in a retail outlet supporting the same shop... in no instances will stock in the pre-expended bin exceed an estimated 30-day supply."

It can be observed at this point that this policy guidance provided makes no attempt to determine levels based on economic considerations or any type of optimization process. The policy is simply stated in terms of number of days supply. This seems to be in conflict with the spirit of DOD Instruction 4140.39 (Ref:11) which specifies the use of economic considerations for inventory decision rules. Additionally a system based on an optimization process has intuitive appeal over a policy based on number of days supply.

## B. NIF STORES

### 1. General

In attempting to implement the inventory management policy, NARF Alameda and NARF Jacksonville manage their NIF store inventories with local procedures. The Alameda procedures have been totally manual, while the Jacksonville procedures include some automated support. The remaining four NARFs use a NAVAIR sponsored system known as the Naval Air Industrial Material Management System (NIMMS). NARF Alameda was planning implementation of the NIMMS system in 1980, and NARF Jacksonville was planning implementation after completion of program changes to be accomplished by the Naval Aviation Logistics Center (NALC).

2. NIMMS

The current version of NIMMS as of this writing was initially implemented at NARF Cherry Point in 1967. It is a batch process system designed for operation on a Burroughs 3500 computer. Although the B-3500 is a third generation real time capable system, the current NIMMS programs were adapted from an earlier card oriented batch system and the real time capabilities of the hardware are not used by NIMMS as it presently is written. A description of the system as written in the user's manual is: (Ref: 12)

> "The NAVAIR Industrial Material Management System (NIMMS) is an Inventory and Fiscal Management System to enable positioning, controlling, costing and accountability of materials and supplies within the NAVAIREWORKFAC by responsible management and operating personnel."
>
> "The system encompasses the requisitioning, receipt, storage, issuance, inventory, reconciliation and inventory accounting necessary to fulfill requirements of depot management and higher authority."
>
> "The NIMMS is designed to enable NAVAIREWORKFAC Material Managers to monitor and regulate the flow of material to production shops, ensuring that optimum goals of minimum inventory investment and maximum material support are achieved."

The Material Planner is a key individual for successful operation of the NIMMS inventory system. The Planner is responsible for the following functions:

1. Nomination of items to be carried as NIF inventory items.

2. Establishment, review, and resetting of stock levels for NIF inventory items.

3. Approval of material substitutions and designation of interchangeable items.

4. Deletion of Navy Industrial Fund Inventory Records (NIFIR) and disposition of stock affected by the deletion.

5. Establishment of a Store Unit of Issue for items issued from a store in increments which differ from standard units of issue.

6. Assignment of replenishment codes to each NIFIR.

7. Maintenance of the NIF inventory file and optional Master Issue Data File.

a. Replenishment Codes

After a Navy Industrial Fund Inventory Record (NIFIR) is established, NIMMS will manage it in accordance with certain system parameters and data contained within the NIFIR. Each NIFIR contains a replenishment code. The possible codes are:

Ø - automatic replenishment using "normal" reorder formula

1 - replenishment by NIMMS is inhibited

2,3,4 - these values affect the computation of the reorder point to compensate for lead time differences

b. Stock Level

Stock Level is defined as the quantity required to be maintained to support production requirements. When a NIFIR is initially established, this quantity is assigned by the Material Planner. During the quarterly processing, the stock level of each NIFIR with replenishment codes other than 1 or 4 is recomputed based on the following formula:

$$\frac{(4 \text{ X } D1) + (3 \text{ X } D2) + (2 \text{ X } D3) + (D4)}{\text{STOCK LEVEL DIVISOR}}$$

Where: D1 = most recent quarterly demand

D2 = second most recent quarterly demand

D3 = third most recent quarterly demand

D4 = fourth most recent quarterly demand

and the Stock Level Divisor is determined by a system parameter known as the Number of Days in Stock Level according to the following relationship:

| Number of Days in Stock Level | Stock Level Divisor |
|---|---|
| ************** | *********** |
| 5Ø | 18 |
| 6Ø | 15 |
| 75 | 12 |
| 9Ø | 1Ø |

The affect of the weighting factors in the numerator is to produce values equal to ten quarters of demand. The Stock Level Divisor then reduces this to an equivalent number of days demand based on the selected Number of Days in Stock Level. (The listed values of 5Ø, 6Ø, 75, and 9Ø are the only choices available for this parameter.) If the replenishment code is 1 or 4, the

recomputation of stock level by NIMMS is inhibited as discussed below.

c. Replenishment Factor

Each replenishment code has an associated replenishment factor that is maintained as a system parameter. The value of the replenishment factors are selected by NARF management and input to NIMMS via parameter cards. The replenishment factors can range from Ø to 9.9.

d. Reorder Point

During daily processing, each transaction that causes a reduction in the on hand balance of a NIFIR causes that record to be tested to determine if replenishment is required. Records with replenishment codes of 1 are not subject to computer generated replenishment. If the replenishment code is not 1, the related replenishment factor divided by the replenishment factor plus one is multiplied by the Stock Level. If this result is greater than or equal to the on hand plus due quantity, then replenishment action is initiated. Therefore the reorder point can be expressed by the formula:

$$\frac{\text{Replenishment Factor X Stock Level}}{1 + \text{Replenishment Factor}}$$

As an example, if the following values are established as system parameters, then the reorder point can be expressed as the indicated percentages of Stock Level:

| Replenishment Code | Replenishment Factor | Reorder Point |
|---|---|---|
| ************* | ************* | ******* |
| 0 | 2.0 | 67% |
| 2 | 1.0 | 50% |
| 3 | 3.0 | 75% |
| 4 | 4.0 | 80% |

NIMMS will also adjust the reorder point for requisition lead time by adjusting the replenishment code each time a receipt is processed. If the replenishment code is not 1 or 4 (these items are excluded from automatic adjustment), the requisition date is subtracted from the current date and the replenishment codes are assigned as follows:

| Number of Days Difference | Replenishment Code Assignment |
|---|---|
| ************** | ****************** |
| 0 - 30 | 2 |
| 31 - 60 | 0 |
| 61 - UP | 3 |

e. Replenishment Review Code

Each NIFIR also contains a replenishment review code that determines whether NIMMS will produce requisitions for submission to the supply system or recommendations for review by the material planner when replenishment action is required.

f. Stratification

Each quarter the NIF store stratification process updates each NIFIR by assigning a stratification category code. The Value of Annual Demand (VAD) is computed for each NIFIR by summing the past four quarters of demand and multiplying this value by the unit price. There are five different stratification codes (numbered 1 thru 5). Each stratification category must have

a low money value assigned to it by input parameter cards; this determines the VAD range for each category. A code is assigned to each NIFIR by determining its VAD and placing it in the appropriate category. The high VAD items are assigned category 1 and the low VAD items are assigned category 5. The purpose of this stratification process as written in the user's manual is: (Ref: 12)

> "The object being to obtain the best requisition effectiveness within authorized investment levels and workload constraints...."

g. Order Quantity

The NARF management must also select the Number of Days in Stock Level parameter from the available choices of 50, 60, 75, or 90. This value is input via parameter cards and is used in the calculation of the order quantity (Q) as shown in the following formula:

$$Q = \text{STOCK LEVEL} \times \text{MULTIPLIER}$$

The multiplier is selected from the following matrix based on the stratification code and the specified Number of Days in Stock Level:

| Stratification Code | Number of Days in Stock Level | | | |
|---|---|---|---|---|
| | 50 | 60 | 75 | 90 |
| 1 | .60 | .50 | .40 | .33 |
| 2 | .90 | .75 | .60 | .50 |
| 3 | 1.20 | 1.00 | .80 | .67 |
| 4 | 1.50 | 1.25 | 1.00 | .83 |
| 5 | 1.80 | 1.50 | 1.20 | 1.00 |

The combined effects of this matrix and the Stock Level

calculation result in the computation of the following actual number of days of stock in the reorder quantity (Q) for each stratification code (assuming the stock level value accurately reflects actual demand requirements):

| Stratification Code | Number of Days of Stock |
|---|---|
| 1 | 30 |
| 2 | 45 |
| 3 | 60 |
| 4 | 75 |
| 5 | 90 |

h. Summary

In summary, the NIMMS inventory model proved to be more complex than was expected for a model designed to maintain a specified number of days stock level in inventory. It is a system with numerous overide and exclusion capabilities that carry a certain danger of effectively "manualizing the automated system". It appears that the selection of the stratification range values is a key decision to successful operation of the model due to its strong impact on inventory levels.

At the time of this writing, the NALC was in the process of a major revision to the NIMMS. The changes to be accomplished include the revision of the operating concept of the system to real time file update and inquiry to make the system responsive to material planner and management needs. The revision plan included adoption of a new inventory model also. However, as of the time of this writing, a model was not developed and approved.

## C. PRE-EXPENDED BINS (PEB)

A pre-expended bin contains high usage, low unit material which has already been expended from the stock records and related financial accounts. The purpose of the pre-expended bin is to facilitate the issue and accounting procedure for recurring issues of these items. The use of the pre-expended system eliminates the time required to fill out a request document, waiting time at the retail outlet counter, and posting of individual issues to stock records. The pre-expended bin is located in the production area and is readily accessable to production personnel. The cost of PEB material is charged to an overhead account. It has been argued that due to the low unit cost and large number of transactions for this type of material, the PEB concept is the most cost effective method of managing this material. The comments made earlier concerning the value of inventories apply also to this material, the only difference is the method of storage and issue. The goal of the PEB system is a more efficient use of available labor through less stringent control on this type of material.

An indication of the magnititude of inventories invested in PEB material is obtained from recent audit reports:

| NARF | Line Items | Value |
|---|---|---|
| Alameda(Ref: 13) | 24,000 | $750,000 - $1,080,000 |
| Norfolk(Ref: 14) | 18,000 | $1,000,000 |
| North Island(Ref: 15) | 28,000 | $900,000 - $1,950,000 |

Common discrepancies noted in audit reports include:

1. Stock levels in excess of 30 day usage

2. Duplicate material in PEB and NIF retail stores

3. Material not properly identified

4. Commingling of material

5. Shelf life material not identified

6. High and low limits not posted on bins

7. Inconsistencies in operating procedures at various locations

PEB operations vary significantly from NARF to NARF. This is the result of a number of different factors such as physical layout, proximity to major supply points, and past as well as current management philosophy. The following information is presented as a brief description of the PEB operations at each NARF. The information was obtained through a limited number of telephone conversations with various NARF personnel. The information is brief and quite likely presents a somewhat biased viewpoint depending on the opinions of the individuals contacted. The purpose of this information is not a highly detailed, accurate description of each operation, but rather to provide a general "flavor" of the different nature of the various operations.

1. Alameda

PEB management at NARF Alameda is the responsibility of the material department. Personnel are assigned to specific PEB operations and are responsible for maintaining records and physical material receipt and stowage as well as reordering when

necessary. Some keypunching service is provided to the PEB operator to facilitate reordering, but the operation is essentially manual. The Alameda system will be covered in more detail in a later section.

2. Cherry Point

PEB management at NARF Cherry Point is the responsibility of the material management division. In the aircraft assembly area the material is readily available to production line workers at designated points on the production floor where the bins are maintained by PEB warehousemen. In the engine overhaul area the PEB material has been consolidated into a controlled access area. Issues are made over the counter based on verbal requests. The records are manually maintained. The determination of what is to be carried as PEB and the high limits are made by material planners. Current plans are to remove the PEB material from the production floor and place it in a controlled access area also. This change is based on the belief that material availibility will be better using the controlled access method.

3. Jacksonville

PEB management at NARF Jacksonville is the responsibility of the production control department. There are two different concepts being used. On the aircraft assembly lines, the PEB material on the shop floor is serviced on a daily basis by a central group from a PEB storeroom using a mobile cart. In the enclosed repair shops, the PEB material is stored on the production floor as individual entities maintained by production control personnel. All records are manually maintained.

4. Norfolk

PEB management at NARF Norfolk is the responsibility of the material department. The operation is essentially run by replenishment of shop floor material from a PEB storeroom by material personnel. Frequent replenishment allows minimal material to be maintained on the shop floors. The material in the storeroom is carried in the NIF stores financial account and is managed using the NIMMS system. At the time of transfer from the storeroom to the production floor, it is expended from the records and charged to the overhead account.

5. North Island

PEB management at NARF North Island is the responsiblilty of the production control department. It is a highly decentralized operation with each production control center being responsible for the management of PEB material for the individual shop areas. The records are maintained on manual cards at each location and there is no visibility between production areas giving information on which items are common.

6. Pensacola

PEB management at NARF Pensacola is the responsibility of the material management division. It is centrally operated as a NIF store using the NIMMS system. The material management personnel do not service the shop floor. Production control personnel from the indiviaual areas request material from the PEB storeroom just as a normal NIF request. Each shop then maintains its own small bins.

## 7. The Alameda System in More Detail

A request for establishment of a PEB item (12ND NARFA 4423/1) can be initiated by a production shop foreman. This form is submitted via a Status and Control Center, where it is audited for correctness, to the cognizant material planner. The request is reviewed by the planner to ensure that the material meets the criteria for management as PEB. If the request is approved, the "30 day stock level" is assigned by the planner based on his estimate of demand. The request is then forwarded to a data entry section where it is established on the mechanized PEB list. It is then forwarded to the appropriate PEB warehouseman who will:

1. Establish a storage location with proper labels (part number, unit of issue, high limit).

2. Initiate a requisition for initial stocks.

3. Establish a stock record card for the material.

After material is receipt-processed, it is stored in the designated bin on the production floor and charged to an overhead account. The warehouseman is responsible for reviewing the areas under his cognizance to determine when replenishment action is necessary. A replenishment requisition is to be submitted whenever the material in the bin has been reduced to one half of the stocking level.

The stocking level can be changed only by approval of a material planner, but it is the responsibility of the warehousemen to recommend changes to the stocking levels or

deletion of items based on experienced demand. As an aid to the warehousemen, there is a color code system being used to help identify items that are not moving. As requisitions for resupply are initiated, a color coded card is returned to the warehouseman and is maintained in the part number reference file. Each year this color code is changed and provides one method to identify items that have not been requisitioned within the current year.

NARF Alameda has an estimated 24,000 different PEB items at 63 different locations throughout the NARF. There are 13 different warehousemen assigned for the management of the PEB operation. This means each warehouseman has an average of about 1850 items he is responsible for. It seems reasonable to conclude that the recurring audit discrepancies are to a large extent a direct result of this single factor. The management of this material is essentially a completely manual process and the major emphasis tends to be on ensuring sufficient material is available in the PEB stowage bins. Available warehouseman time tends to be fully occupied reviewing the material in the bins, initiating procurement, and restocking bins. Manual review of stock records is a tedious and time consuming process that is quite easily relegated to the list of things to do later in the face of each day's problems of supporting the production shops. The result is that when an item is initially established as a PEB item with a certain stock level, it tends to remain unchanged regardless of demand and ultimately becomes the source of recurring audit discrepancies.

# IV. THE PROPOSED SYSTEM

## A. Practical Considerations

In the development of a proposed system for PEB material, it is important to keep in mind the nature of the problem and how this material relates to overall NARF operations. As previously noted, PEB material consists of relatively low-cost, high-usage items for which it has been acknowledged that less stringent management control is desirable. Justification for this approach follows the logic that it is not "worth $25 worth of control system to prevent $3 worth of stock getting lost." (Ref: 16) While this argument is certainly valid, there is a basic control need to insure that the material is demanded with sufficient frequency that PEB concepts are justified. This is emphasized by the fact that much audit criticism has been leveled at excessive depths of material and the retention of material that is no longer demanded.

With this in mind, it seems that the important considerations in an improved PEB management system are: first, it should contain a method for determining that the correct material is being managed under PEB concepts; second, it should contain a method for determining the correct levels of PEB material; and, finally, it must be implementable at low cost.

### 1. Determination of On Hand Quantity

The PEB concept specifies less stringent control with no documentation required for individual issues. This presents a problem in determining the on hand quantity at any given time,

since stock records with current values of on hand quantity are not maintained. As a result, the determination of the on hand quantity is typically accomplished through a cursory visual review process since it is not practical to physically count the several hundred washers, bolts, o-rings, and similar hardware items contained in each bin. The review consists of estimating the on hand quantity based on a visual approximation (ie, "that looks like about 100 washers"). This estimate is then compared to the reorder point to determine whether a replenishment action is necessary.

Since the real use of the review is for reorder purposes, the process could be facilitated by the use of a "two-bin" concept for many items. As an example, consider an item such as a small bolt for which the order quantity and reorder point have been determined. The amount of space occupied in the bin by the quantity equal to the reorder point could be physically marked on the bin in some manner so the reorder point can be determined at a glance. Since a two-bin system physically separates the material by the use of two individual containers or by sealing some material in an inner container, the proposed PEB system will not be a true two-bin system. However, this concept could reduce the amount of time required for the review process and allow more frequent reviews of all bins.

2. The Use of a Continuous Review Model

The visual review of PEB material is technically a periodic review process. However, if the time between reviews is sufficiently short, the differences between periodic and

continuous review systems become negligible. Since the continuous review model is in general easier to deal with and leads to lower inventory investment levels, it is preferable to the pericdic review model. (Ref: 5)

## B. The Model

A simple order point--order quantity (s,Q) policy is recommended. For depth determinations, the two control variables are the reorder point and order quantity. The reorder point represents an inventory level which should be large enough to satisfy the anticipated average demand during the replenishment lead time plus some safety factor. The order quantity represents a form of the classic economic order quantity.

### 1. Determination of Q

The order quantity (Q) is expressed in the following formula:

$$Q = \sqrt{\frac{8AD}{IC}}$$

where: A = the ordering cost, in dollars per order.

D = the demand rate, in units per quarter.

I = the inventory carrying charge, in dollars per dollar of inventory per unit time.

C = the unit cost of the item, in dollars per unit.

2. Determination of s

The order point (s) is expressed in the following formula:

$$s = u + SS$$

where: u = expected demand during procurement lead time.

SS = safety stock to protect against uncertainty in the expected demand during procurement lead time.

There are two basic approaches to calculating the mean and variance of lead time demand required for calculation of the reorder point (Ref: 17). One method uses direct measurement of actual demand during actual lead times. The second method uses separate estimations of the distributions of demand and lead time. These two separate distributions are then combined to predict demand during lead time. The first method is not appropriate for the proposed system because of the additional data gathering requirements.

Fetter and Dalleck (Ref: 18) give several examples for the calculation of demand during lead time using both numerical and Monte Carlo simulation techniques. If both demand and lead time are random variables, the numerical method involves expanding and summing the terms of a multinomial expression representing the combined probabilities of the possible combinations of lead time and demand. In the Monte Carlo method, the variable demand and variable lead time are combined by simulating demand as it occurs during successive lead time periods through the use of the

probability distributions associated with each event. Both of these methods require numerous calculations and are beyond the capability of the recommended system as presented above. However, if the assumption is made that the demand during lead time is normally distributed, then the values for the mean and variance of lead time demand are easily computed from the values of the mean and variance of demand and the mean and variance of lead time. This is expressed by the following formulas: (Ref: 18)

$$u = DL$$

where: u = the mean demand during lead time.

D = the mean demand per quarter.

L = the mean lead time in quarters.

and

$$\tilde{o}_u^2 = L\,\tilde{o}_d^2 + D^2\,\tilde{o}_l^2$$

where: $\tilde{o}_u^2$ = the variance of demand during lead time.

L = the mean lead time in quarters.

$\tilde{o}_d^2$ = the variance of quarterly demand.

$\tilde{o}_l^2$ = the variance of lead time.

The safety stock may now be determined by the following formula:

$$SS = k\,\tilde{o}_u$$

where: $\tilde{o}_u$ = the standard deviation of lead time demand (the square root of the variance)

$k$ = a value representing the desired service level of the system

Since the demand during lead time has been assumed to be normally distributed, the value for k can be determined from the standard normal cumulative distribution function based on the desired level of service. In this context, the desired service level is determined by the willingness to accept a given risk of a stockout. For the normal distribution, a safety stock level of 0 implies a stockout risk of 50 percent during each order cycle (and the service level is 100 - 50 or 50 percent). If the service level is to be increased by reducing the stockout risk, then the safety stock must be increased.

For low values of effectiveness, the increase in safety stock is roughly proportional to the increase in desired service level. That is, the amount of safety stock required to increase the service level from 80 to 85 percent is only slightly greater than the amount required to increase the service level from 75 to 80 percent. As the service level approaches 100 percent, this relationship changes significantly. The same amount of safety stock is required to increase the service level from 95 to 99 percent as is required to increase it from 64 to 85 percent

(Ref:17). Therefore, service levels of around 90 percent seem to offer a reasonable balance between acceptable risk and marginal cost of safety stock.

3. Determination of the Range of Items

Ideally the decision rules for range determination should be based on economic considerations. The cost of managing the item as PEB would be compared to the cost of not managing the item as PEB and the alternative with the lowest annual cost would be selected. Unfortunately, the determination of the above costs is beyond the scope of the proposed system. Therefore, another method is needed to determine the range of items.

The present PEB management system requires that a material planner review each request for establishment of a new item. The item is approved for stocking if it meets the required PEB criteria and the anticipated demand is greater than a threshold value of 10 per month. This threshold value seems to have embedded in it some implicit consideration of the cost differential between stocking or not stocking the item as PEB. It is recommended that the proposed system also use this concept of a threshold value of some minimum demand as the criteria for range determination. The selection of the actual value to use is a management policy decision that should be made at an appropriate management level and then standardized for all items. The present value of 10 per month (30 per quarter) seems to be a reasonable threshold value.

After an item has been stocked as PEB, it is possible that the actual demand level may eventually become substantially lower

than the demand anticipated when it was established as a PEB item. It is therefore important that some method be provided for reviewing the items to determine whether they should be deleted from the PEB system or not. It is recommended that a second threshold value be used to delete items and that it be lower than the value used to add items. Its value should prevent items from being established one quarter and then deleted the following quarter. Additionally, it seems appropriate that items should be required to be below the delete threshold for two consecutive quarters before they are deleted. This also will help to eliminate excessive adds and deletes. If a minimum demand of 30 per quarter is required to establish an item as PEB, then a demand of 15 per quarter seems to be a reasonable value for the delete threshold.

# V. IMPLEMENTATION ISSUES

## A. The Data Base

The first issue discussed will be the required data base to support operation of the improved PEB management system. A computer-based system offers significant advantages in terms of flexibility and computation speed. However, even though the necessary hardware is probably readily available to the NARFs, it is not likely that the required software development effort would be expended on a PEB management system due to the limited number of systems development personnel and higher priority demands for their time. Therefore, the use of a manual system is recommended.

### 1. Ordering and Holding Costs

Estimates for ordering costs and inventory holding costs must be available. These parameters could be assumed to be the same for all items and computed as average values. The recommended approach for estimating ordering costs is to determine an average time required to perform the ordering and receiving actions (including documentation). This time could then be multiplied by a standard cost rate. This estimate should be kept current by annual reviews.

DODINST 4140.39 (Ref: 11) specifies the following values for the variable cost-to-hold rate:

| Element | Value |
|---|---|
| Investment Cost | 10% per dollar per year |
| Storage Cost | 1% per dollar per year |
| Obsolescence Cost | Variable |
| Other Losses | Variable |

If no other data is available, it is recommended that the obsolescence cost be assigned as 5 per cent, and other losses be assigned as 4 per cent. This will result in a total holding cost rate of 20 per cent which is similar to the holding cost rates used by SPCC and ASO in the UICP Models. However, if the NARF records indicate that some other values for these costs are appropriate then they should be used instead.

2. Item Unique Values

Additionally, the data base must provide the unit cost and estimates of the following demand parameters for each item being managed:

1. Demand rate
2. Lead time
3. Variability of demand during lead time

The form shown in Appendix A provides a format for collecting the required information. It is recommended that this form be printed on the outside of a large (8 1/2 X 11) envelope. These envelopes could then be used as stock records for PEB items and would keep the required information in a convenient format to facilitate updating of the records. The envelope provides a storage place for prepunched computer cards to be used for ordering and follow-up of outstanding requisitions. This would

provide the same mechanized support as the present Alameda system. As orders are submitted and received, the order record portion of the stock record would be updated by entering the quantity, order date, and receipt date for each order.

B. Computations

After the end of a quarter and before a new replenishment requisition is submitted, the quarterly summary portion of the stock record must be updated. New stock levels are then computed from the updated values.

The reorder point (s) is based in part on the standard deviation of demand during lead time. In the previous chapter it was shown how this could be calculated using the means and variances of demand and lead time. What is now needed is a method of determining the variances of demand and lead time.

The most easily computed measure of dispersion is the mean absolute deviation (MAD) (Ref: 17). The MAD is the average of the absolute value of the differences between observed values and the mean value. It has been shown that for a normal distribution, the variance is equal to 1.57 times the MAD. Therefore, a good estimate for the required variances can be obtained from the easily computed MAD values.

To obtain updated estimates for mean demand, MAD of demand, mean lead time, and MAD of lead time an exponential smoothing process is used. This is expressed by the following formula:

$$\text{New Value} = (1-a)(\text{Old Value}) + (a)(\text{New Observation})$$

The value (a) is a weighting factor with a recommended value of 0.1 (Ref: 19). The exponential process does not require repeated calculations of a long historical demand record and smoothes the fluctuations in the demand history to provide a stable estimate for the required parameters.

The stock record is updated quarterly as follows. The observed demand for the quarter is the sum of the individual orders processed during the quarter. The smoothed mean demand is then calculated using the observed demand and the previous quarter's smoothed mean demand as inputs to the exponential smoothing formula. Next, a new observed MAD of demand is determined by taking the absolute value of the difference between the current observed demand and the previous quarter's smoothed mean demand. This new observed MAD of demand and the previous quarter's MAD of demand are used to calculate the new smoothed MAD of demand.

The lead time for each order processed during the quarter is determined by subtracting the date of the order from the date of the receipt. A new smoothed mean lead time is then calculated using the new order lead time and the previous quarter's smoothed mean lead time. A new observed MAD of lead time is determined by taking the absolute value of the difference between the new lead time and the previous quarter's smoothed mean lead time. This new observed MAD of lead time and the previous quarter's MAD of lead time are used to calculate the new MAD of lead time. If there was more than one order processed during the quarter, the lead time calculation is repeated for each order, however, only the last

values for smoothed mean lead time and MAD of lead time are entered on the stock record.

The smoothed mean demand is then used in the formula on page 35 to update the order quantity (Q) on the stock record. The smoothed mean demand, MAD of demand, mean lead time, and MAD of lead time are used in the formulas on pages 36 through 38 to calculate the new reorder point (s). The required computations can be easily programmed on one of the widely-available and relatively-inexpensive programmable calculators such as the Texas Instruments TI-59. This will make the updating of the records much easier and faster than would otherwise be possible. A TI-59 program designed to accept the observed information from the stock record and calculate revised smoothed values and the reorder point and order quantity is provided in Appendix B. The program is designed to be used with a printer (PC-100A) and provides prompting messages to keep operator training requirements low and to reduce errors. The program is also designed to provide an exception message when the calculated smoothed demand is below the delete threshold value. This is an aid to the PEB warehouseman in identifying candidates for deletion. An example of the sequence involved in updating a stock record is shown in Appendix C.

It must be emphasized that the proposed system depends on the PEB warehouseman to regularly update the stock records. The action required to improve the management of the PEB items depends on the data recorded on the stock record. If this data is not current then the management of PEB items will not be

improved.

## C. A "30 Day" Constrained Model

The proposed system determines the order quantity (Q) based on economic considerations instead of a "30 day supply" as specified in the NAVCOMPT Manual (Ref: 9). If the proposed system is adopted as presented, a request for departure from the NAVCOMPT Manual policy should be submitted via the chain of command. If the approval of this request becomes a problem, a constraint could be added to the model that would limit the order quantity to an equivalent of 30 days usage based on the smoothed demand rate. This should satisfy the policy requirement and still provide an improved management system. A TI-59 program listing that incorporates this change is also provided in Appendix B.

## D. The Role of the Planner

Material planner review for all additions, deletions, and quantity changes has been required in the past, and it is highly recommended that this policy be continued. The planner may be aware of situations which make the decisions of the proposed system inappropriate. The planner review process should be designed to inform the planner of deletions and quantity changes that will be made unless he overrides the decision. This will prevent a planner from being able to make the entire system ineffective by inaction while providing him with information and the authority to override the system decisions. Range adds should be accomplished as in the past except instead of a "30-day stock level" the planner should provide an estimate of quarterly demand

that would be used as an initial entry on the stock record for use in computing levels.

The number of planner overrides should be a relatively small number of exceptions in terms of the overall system. The reason for each exception should be clearly specified in a memorandum that is kept inside the stock record envelope. The outside of the envelope should be annotated with the date the exception is established, and all exceptions should be reviewed at least annually.

## E. An Implementation Plan

The proposed system is a change from the previous way in which the PEB material has been managed. An organized plan is therefore required to implement the change in an orderly manner. Although the actual implementation of this proposed system is not a complicated process, it will probably take over a year to accomplish properly. This is partly due to the time required to gather data to be used in the proposed system. Additionally it will have to be implemented in an incremental and organized manner, as it will represent a significant work effort on the part of the PEB warehousemen.

The information required for the operation of the proposed system will probably not be available and will require some time to accumulate. It is recommended that the order quantities and reorder points not be calculated with this system until at least two quarters of demand information have been accumulated.

Another problem that might be encountered during implementation is that a large number of items may appear to have no demand after the first two quarters of operation under the new system. The correct reaction to this condition would seem to be to remove all of these items from the PEB system. Some caution is required here, however, to insure that items are not removed that should be retained. If the established high limit has been such that the quantities in the bins have been larger than two quarters of demand, then the stock record would not reflect any demand, even though the item is being used on the shop floor. Therefore, when items are first considered for deletion from the system, an additional step should be taken to ensure the item in fact has no demand. This could be accomplished by physically sealing all but a small quantity of the material in the bin in some sort of package and leaving it in the bin. An accurate determination of whether the material is being used or not could then be made relatively quickly. Another alternative would be to paint a "depth gauge" on the side of the bin. This could be simply a series of marks to indicate the quantity of stock corresponding to that level in the bin. The reorder point could also be marked on this gauge using a sticker that could be easily changed when necessary.

Another type of depth gauge would be a small ruler with the quantity level marks on it which could be fastened to the side of the bin. This would eliminate the problems associated with trying to paint marks on the bin. A pair of sliding pointers could also be attached to this gauge. The lower pointer could be used to

mark the reorder point. The upper pointer could be set to the level of stock in the bin after receipt of a new order or at the current level each time a review is made. This upper pointer would then provide an indication of usage for the slower moving items when they are being reviewed for possible deletion from the PEB system.

## VI. Conclusions and Recommendations

This thesis has reviewed some of the NARF procedures for management of PEB material. It was noted that the values of inventory invested in PEB material is about one million dollars per NARF. It is recommended that an inventory of this size receive more management attention than has been the case in the past. A proposal for a management system based on a continuous review (Q,s) inventory model was made. It is believed that the proposed system offers improvements through the standardization of decision rules and by providing an easily maintained demand history record to be used as a basis for the decisions. The calculation requirements to support the proposed system are simplified by the use of a programmable calculator.

The deletion of material that is not being used is probably the most important improvement that can be made in the management of PEB material. This action reduces the number of items being managed by each warehouseman allowing more attention to the items that are important to the production process. This also reduces the amount of PEB material with very low usage which has been the most significant source of audit discrepancies.

The proposal will have a better chance of success if there is a single "project manager" in charge of its implementation. This manager must have sufficient authority and be capable of providing guidance and motivation to the individual PEB warehousemen. Additionally, the system should be operated under centralized management to provide uniformity throughout the NARF.

It is recommended that further study be conducted concerning the threshold values for range adds and deletes to discover if a simple analytical method for determining the decision rules can be developed. It is further recommended that the possibility of managing PFB material using the MRP system be investigated after the MRP system has become fully operational.

APPENDIX: A

PART NUMBER__________________ LATEST UNIT COST_______________

NSN __________________________ ______________________________

**QUARTERLY SUMMARY**

| QTR | OBSERVED DEMAND | SMOOTHED MEAN DEMAND | SMOOTHED MAD OF DEMAND | SMOOTHED MEAN LEADTIME | SMOOTHED MAD OF LEADTIME | C | S |
|---|---|---|---|---|---|---|---|
| JAN | | | | | | | |
| MAR | | | | | | | |
| JUL | | | | | | | |
| OCT | | | | | | | |
| JAN | | | | | | | |
| MAR | | | | | | | |
| JUL | | | | | | | |
| OCT | | | | | | | |

**ORDER RECORD**

| QTY | JULIAN DATE ORDERED | JULIAN DATE RECEIVED | QTY | JULIAN DATE ORDERED | JULIAN DATE RECEIVED |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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## APPENDIX: B

The following TI-59 program is designed to accept input information from the stock record and calculate new values for:

1. Smoothed mean demand
2. Smoothed MAD of demand
3. Smoothed mean lead time
4. Smoothed MAD of lead time
5. Order quantity (Q)
6. Reorder point (s)

The program requires that the calculator partition be set at 799.19 and that a PC-100A be used.

The following registers are used by the program:

6 - New smoothed lead time (calculated)
7 - New MAD of lead time (calculated)
8 - Date of receipt (input)
9 - Date of order (input)
10 - Unit cost (input)
11 - Observed demand (input)
12 - Observed lead time (calculated)
13 - Old smoothed demand (input)
14 - Old MAD of demand (input)
15 - Old smoothed lead time (input)
16 - Old MAD of lead time (input)
17 - New smoothed demand (calculated)
18 - New MAD of demand (calculated)

The program uses the following labels:

| | | |
|---|---|---|
| 001 | 11 | A |
| 255 | 99 | PRT |
| 330 | 12 | B |
| 486 | 95 | = |
| 509 | 90 | LST |
| 585 | 13 | C |
| 622 | 37 | P/R |
| 696 | 97 | DSZ |

The program assumes that all demand data is in units per quarter. As a matter of operator convenience, the lead time is assumed to be in days. The program converts the days to quarters for use in calculation of the reorder point.

The parameters for ordering cost, holding cost, and service level are built into the program as constants. Assumed values were used for demonstration purposes. These values can be changed by changing the program code at the following locations:

| | |
|---|---|
| Ordering cost | 594-595 |
| Holding cost | 602-603 |
| Service level | 658-663 |

To begin update of a record, press A. Prompting messages are printed during program execution to request input data and define output values. When the program requests an input value, the number should be entered followed by the R/S key.

| | | |
|---|---|---|
| 000 | 76 | LBL |
| 001 | 11 | A |
| 002 | 25 | CLR |
| 003 | 69 | OP |
| 004 | 00 | 00 |
| 005 | 01 | 1 |
| 006 | 07 | 7 |
| 007 | 03 | 3 |
| 008 | 01 | 1 |
| 009 | 03 | 3 |
| 010 | 07 | 7 |
| 011 | 01 | 1 |
| 012 | 07 | 7 |
| 013 | 03 | 3 |
| 014 | 05 | 5 |
| 015 | 69 | OP |
| 016 | 01 | 01 |
| 017 | 01 | 1 |
| 018 | 05 | 5 |
| 019 | 03 | 3 |
| 020 | 02 | 2 |
| 021 | 03 | 3 |
| 022 | 06 | 6 |
| 023 | 03 | 3 |
| 024 | 07 | 7 |
| 025 | 69 | OP |
| 026 | 02 | 02 |
| 027 | 69 | OP |
| 028 | 05 | 05 |
| 029 | 25 | CLR |
| 030 | 91 | R/S |
| 031 | 99 | PRT |
| 032 | 98 | ADV |
| 033 | 42 | STO |
| 034 | 10 | 10 |
| 035 | 03 | 3 |
| 036 | 02 | 2 |
| 037 | 01 | 1 |
| 038 | 04 | 4 |
| 039 | 03 | 3 |

| | | |
|---|---|---|
| Ø4Ø | Ø6 | 6 |
| Ø41 | 69 | OP |
| Ø42 | Ø2 | Ø2 |
| Ø43 | Ø1 | 1 |
| Ø44 | Ø6 | 6 |
| Ø45 | Ø3 | 3 |
| Ø46 | ØØ | Ø |
| Ø47 | Ø1 | 1 |
| Ø48 | Ø6 | 6 |
| Ø49 | 69 | OP |
| Ø5Ø | Ø3 | Ø3 |
| Ø51 | 69 | OP |
| Ø52 | Ø5 | Ø5 |
| Ø53 | 25 | CLR |
| Ø54 | 91 | R/S |
| Ø55 | 99 | PRT |
| Ø56 | 98 | ADV |
| Ø57 | 42 | STO |
| Ø58 | 11 | 11 |
| Ø59 | Ø3 | 3 |
| Ø6Ø | Ø2 | 2 |
| Ø61 | Ø2 | 2 |
| Ø62 | Ø7 | 7 |
| Ø63 | Ø1 | 1 |
| Ø64 | Ø6 | 6 |
| Ø65 | 69 | OP |
| Ø66 | Ø2 | Ø2 |
| Ø67 | Ø3 | 3 |
| Ø68 | ØØ | Ø |
| Ø69 | Ø1 | 1 |
| Ø7Ø | Ø7 | 7 |
| Ø71 | Ø1 | 1 |
| Ø72 | Ø3 | 3 |
| Ø73 | Ø3 | 3 |
| Ø74 | Ø1 | 1 |
| Ø75 | 69 | OP |
| Ø76 | Ø3 | Ø3 |
| Ø77 | Ø1 | 1 |
| Ø78 | Ø6 | 6 |
| Ø79 | Ø3 | 3 |
| Ø8Ø | ØØ | Ø |
| Ø81 | Ø1 | 1 |
| Ø82 | Ø6 | 6 |
| Ø83 | 69 | OP |
| Ø84 | Ø4 | Ø4 |
| Ø85 | 69 | OP |
| Ø86 | Ø5 | Ø5 |
| Ø87 | 25 | CLR |
| Ø88 | 91 | R/S |
| Ø89 | 42 | STO |
| Ø9Ø | 13 | 13 |
| Ø91 | 99 | PRT |
| Ø92 | 98 | ADV |
| Ø93 | Ø3 | 3 |

| | | |
|---|---|---|
| 094 | 00 | 0 |
| 095 | 01 | 1 |
| 096 | 03 | 3 |
| 097 | 01 | 1 |
| 098 | 06 | 6 |
| 099 | 69 | OP |
| 100 | 03 | 03 |
| 101 | 69 | OP |
| 102 | 05 | 05 |
| 103 | 25 | CLR |
| 104 | 91 | R/S |
| 105 | 42 | STO |
| 106 | 14 | 14 |
| 107 | 99 | PRT |
| 108 | 98 | ADV |
| 109 | 00 | 0 |
| 110 | 69 | OP |
| 111 | 01 | 01 |
| 112 | 03 | 3 |
| 113 | 01 | 1 |
| 114 | 01 | 1 |
| 115 | 07 | 7 |
| 116 | 04 | 4 |
| 117 | 03 | 3 |
| 118 | 69 | OP |
| 119 | 02 | 02 |
| 120 | 03 | 3 |
| 121 | 00 | 0 |
| 122 | 01 | 1 |
| 123 | 07 | 7 |
| 124 | 01 | 1 |
| 125 | 03 | 3 |
| 126 | 03 | 3 |
| 127 | 01 | 1 |
| 128 | 69 | OP |
| 129 | 03 | 03 |
| 130 | 53 | ( |
| 131 | 93 | . |
| 132 | 09 | 9 |
| 133 | 65 | X |
| 134 | 43 | RCL |
| 135 | 13 | 13 |
| 136 | 85 | + |
| 137 | 93 | . |
| 138 | 01 | 1 |
| 139 | 65 | X |
| 140 | 43 | RCL |
| 141 | 11 | 11 |
| 142 | 54 | ) |
| 143 | 42 | STO |
| 144 | 17 | 17 |
| 145 | 69 | OP |
| 146 | 05 | 05 |
| 147 | 99 | PRT |

| | | |
|---|---|---|
| 148 | 98 | ADV |
| 149 | 03 | 3 |
| 150 | 00 | 0 |
| 151 | 01 | 1 |
| 152 | 03 | 3 |
| 153 | 01 | 1 |
| 154 | 06 | 6 |
| 155 | 69 | OP |
| 156 | 03 | 03 |
| 157 | 53 | ( |
| 158 | 53 | ( |
| 159 | 43 | RCL |
| 160 | 11 | 11 |
| 161 | 75 | - |
| 162 | 43 | RCL |
| 163 | 13 | 13 |
| 164 | 54 | ) |
| 165 | 50 | \|X\| |
| 166 | 65 | X |
| 167 | 93 | . |
| 168 | 01 | 1 |
| 169 | 85 | + |
| 170 | 43 | RCL |
| 171 | 14 | 14 |
| 172 | 65 | X |
| 173 | 93 | . |
| 174 | 09 | 9 |
| 175 | 54 | ) |
| 176 | 42 | STO |
| 177 | 18 | 18 |
| 178 | 69 | OP |
| 179 | 05 | 05 |
| 180 | 99 | PRT |
| 181 | 98 | ADV |
| 182 | 01 | 1 |
| 183 | 07 | 7 |
| 184 | 03 | 3 |
| 185 | 01 | 1 |
| 186 | 03 | 3 |
| 187 | 07 | 7 |
| 188 | 01 | 1 |
| 189 | 07 | 7 |
| 190 | 03 | 3 |
| 191 | 05 | 5 |
| 192 | 69 | OP |
| 193 | 01 | 01 |
| 194 | 03 | 3 |
| 195 | 02 | 2 |
| 196 | 02 | 2 |
| 197 | 07 | 7 |
| 198 | 01 | 1 |
| 199 | 06 | 6 |
| 200 | 00 | 0 |
| 201 | 00 | 0 |

| | | |
|---|---|---|
| 2Ø2 | 69 | OP |
| 2Ø3 | Ø2 | Ø2 |
| 2Ø4 | Ø3 | 3 |
| 2Ø5 | ØØ | Ø |
| 2Ø6 | Ø1 | 1 |
| 2Ø7 | Ø7 | 7 |
| 2Ø8 | Ø1 | 1 |
| 2Ø9 | Ø3 | 3 |
| 21Ø | Ø3 | 3 |
| 211 | Ø1 | 1 |
| 212 | ØØ | Ø |
| 213 | ØØ | Ø |
| 214 | 69 | OP |
| 215 | Ø3 | Ø3 |
| 216 | Ø2 | 2 |
| 217 | Ø7 | 7 |
| 218 | Ø3 | 3 |
| 219 | Ø7 | 7 |
| 22Ø | Ø2 | 2 |
| 221 | Ø4 | 4 |
| 222 | Ø3 | 3 |
| 223 | ØØ | Ø |
| 224 | Ø1 | 1 |
| 225 | Ø7 | 7 |
| 226 | 69 | OP |
| 227 | Ø4 | Ø4 |
| 228 | 69 | OP |
| 229 | Ø5 | Ø5 |
| 23Ø | 25 | CLR |
| 231 | 91 | R/S |
| 232 | 42 | STO |
| 233 | 15 | 15 |
| 234 | 99 | PRT |
| 235 | 98 | ADV |
| 236 | Ø3 | 3 |
| 237 | ØØ | Ø |
| 238 | Ø1 | 1 |
| 239 | Ø3 | 3 |
| 24Ø | Ø1 | 1 |
| 241 | Ø6 | 6 |
| 242 | ØØ | Ø |
| 243 | ØØ | Ø |
| 244 | 69 | OP |
| 245 | Ø3 | Ø3 |
| 246 | 69 | OP |
| 247 | Ø5 | Ø5 |
| 248 | 25 | CLR |
| 249 | 91 | R/S |
| 25Ø | 42 | STO |
| 251 | 16 | 16 |
| 252 | 99 | PRT |
| 253 | 98 | ADV |
| 254 | 76 | LBL |
| 255 | 99 | PRT |

| | | |
|---|---|---|
| 256 | 03 | 3 |
| 257 | 03 | 3 |
| 258 | 03 | 3 |
| 259 | 05 | 5 |
| 260 | 01 | 1 |
| 261 | 07 | 7 |
| 262 | 03 | 3 |
| 263 | 06 | 6 |
| 264 | 03 | 3 |
| 265 | 06 | 6 |
| 266 | 69 | OP |
| 267 | 01 | 01 |
| 268 | 01 | 1 |
| 269 | 04 | 4 |
| 270 | 00 | 0 |
| 271 | 00 | 0 |
| 272 | 03 | 3 |
| 273 | 07 | 7 |
| 274 | 03 | 3 |
| 275 | 02 | 2 |
| 276 | 69 | OP |
| 277 | 02 | 02 |
| 278 | 01 | 1 |
| 279 | 05 | 5 |
| 280 | 01 | 1 |
| 281 | 03 | 3 |
| 282 | 02 | 2 |
| 283 | 07 | 7 |
| 284 | 00 | 0 |
| 285 | 00 | 0 |
| 286 | 69 | OP |
| 287 | 03 | 03 |
| 288 | 02 | 2 |
| 289 | 07 | 7 |
| 290 | 03 | 3 |
| 291 | 07 | 7 |
| 292 | 02 | 2 |
| 293 | 04 | 4 |
| 294 | 03 | 3 |
| 295 | 00 | 0 |
| 296 | 01 | 1 |
| 297 | 07 | 7 |
| 298 | 69 | OP |
| 299 | 04 | 04 |
| 300 | 69 | OP |
| 301 | 05 | 05 |
| 302 | 01 | 1 |
| 303 | 05 | 5 |
| 304 | 00 | 0 |
| 305 | 00 | 0 |
| 306 | 03 | 3 |
| 307 | 07 | 7 |
| 308 | 03 | 3 |
| 309 | 02 | 2 |

| | | |
|---|---|---|
| 310 | 69 | OP |
| 311 | 02 | 02 |
| 312 | 03 | 3 |
| 313 | 04 | 4 |
| 314 | 00 | 0 |
| 315 | 00 | 0 |
| 316 | 04 | 4 |
| 317 | 07 | 7 |
| 318 | 00 | 0 |
| 319 | 00 | 0 |
| 320 | 03 | 3 |
| 321 | 06 | 6 |
| 322 | 69 | OP |
| 323 | 04 | 04 |
| 324 | 69 | OP |
| 325 | 05 | 05 |
| 326 | 25 | CLR |
| 327 | 98 | ADV |
| 328 | 92 | RTN |
| 329 | 76 | LBL |
| 330 | 12 | B |
| 331 | 01 | 1 |
| 332 | 07 | 7 |
| 333 | 03 | 3 |
| 334 | 01 | 1 |
| 335 | 03 | 3 |
| 336 | 07 | 7 |
| 337 | 01 | 1 |
| 338 | 07 | 7 |
| 339 | 03 | 3 |
| 340 | 05 | 5 |
| 341 | 69 | OP |
| 342 | 01 | 01 |
| 343 | 01 | 1 |
| 344 | 06 | 6 |
| 345 | 01 | 1 |
| 346 | 03 | 3 |
| 347 | 03 | 3 |
| 348 | 07 | 7 |
| 349 | 01 | 1 |
| 350 | 07 | 7 |
| 351 | 69 | OP |
| 352 | 02 | 02 |
| 353 | 03 | 3 |
| 354 | 02 | 2 |
| 355 | 03 | 3 |
| 356 | 05 | 5 |
| 357 | 01 | 1 |
| 358 | 06 | 6 |
| 359 | 69 | OP |
| 360 | 03 | 03 |
| 361 | 00 | 0 |
| 362 | 69 | OP |
| 363 | 04 | 04 |

| | | |
|---|---|---|
| 364 | 69 | OP |
| 365 | Ø5 | Ø5 |
| 366 | 91 | R/S |
| 367 | 42 | STO |
| 368 | Ø9 | Ø9 |
| 369 | 99 | PRT |
| 37Ø | 98 | ADV |
| 371 | Ø3 | 3 |
| 372 | Ø5 | 5 |
| 373 | Ø1 | 1 |
| 374 | Ø7 | 7 |
| 375 | Ø1 | 1 |
| 376 | Ø5 | 5 |
| 377 | 69 | OP |
| 378 | Ø3 | Ø3 |
| 379 | 69 | OP |
| 38Ø | Ø5 | Ø5 |
| 381 | 25 | CLR |
| 382 | 91 | R/S |
| 383 | 42 | STO |
| 384 | Ø8 | Ø8 |
| 385 | 99 | PRT |
| 386 | 98 | ADV |
| 387 | ØØ | Ø |
| 388 | 69 | OP |
| 389 | Ø1 | Ø1 |
| 39Ø | Ø3 | 3 |
| 391 | Ø1 | 1 |
| 392 | Ø1 | 1 |
| 393 | Ø7 | 7 |
| 394 | Ø4 | 4 |
| 395 | Ø3 | 3 |
| 396 | ØØ | Ø |
| 397 | ØØ | Ø |
| 398 | 69 | OP |
| 399 | Ø2 | Ø2 |
| 4ØØ | Ø3 | 3 |
| 4Ø1 | ØØ | Ø |
| 4Ø2 | Ø1 | 1 |
| 4Ø3 | Ø7 | 7 |
| 4Ø4 | Ø1 | 1 |
| 4Ø5 | Ø3 | 3 |
| 4Ø6 | Ø3 | 3 |
| 4Ø7 | Ø1 | 1 |
| 4Ø8 | ØØ | Ø |
| 4Ø9 | ØØ | Ø |
| 41Ø | 69 | OP |
| 411 | Ø3 | Ø3 |
| 412 | Ø2 | 2 |
| 413 | Ø7 | 7 |
| 414 | Ø3 | 3 |
| 415 | Ø7 | 7 |
| 416 | Ø2 | 2 |
| 417 | Ø4 | 4 |

| | | |
|---|---|---|
| 418 | Ø3 | 3 |
| 419 | ØØ | Ø |
| 42Ø | Ø1 | 1 |
| 421 | Ø7 | 7 |
| 422 | 69 | OP |
| 423 | Ø4 | Ø4 |
| 424 | Ø1 | 1 |
| 425 | ØØ | Ø |
| 426 | ØØ | Ø |
| 427 | ØØ | Ø |
| 428 | 22 | INV |
| 429 | 49 | PRD |
| 43Ø | Ø8 | Ø8 |
| 431 | 22 | INV |
| 432 | 49 | PRD |
| 433 | Ø9 | Ø9 |
| 434 | 43 | RCL |
| 435 | Ø8 | Ø8 |
| 436 | 59 | INT |
| 437 | 22 | INV |
| 438 | 44 | SUM |
| 439 | Ø8 | Ø8 |
| 44Ø | 32 | X<>T |
| 441 | 43 | RCL |
| 442 | Ø9 | Ø9 |
| 443 | 59 | INT |
| 444 | 22 | INV |
| 445 | 44 | SUM |
| 446 | Ø9 | Ø9 |
| 447 | 67 | EQ |
| 448 | 95 | = |
| 449 | 53 | ( |
| 45Ø | 32 | X<>T |
| 451 | 75 | - |
| 452 | 32 | X<>T |
| 453 | 54 | ) |
| 454 | 29 | CP |
| 455 | 22 | INV |
| 456 | 77 | GE |
| 457 | 97 | DSZ |
| 458 | Ø1 | 1 |
| 459 | ØØ | Ø |
| 46Ø | ØØ | Ø |
| 461 | ØØ | Ø |
| 462 | 49 | PRD |
| 463 | Ø8 | Ø8 |
| 464 | 49 | PRD |
| 465 | Ø9 | Ø9 |
| 466 | 53 | ( |
| 467 | 53 | ( |
| 468 | 43 | RCL |
| 469 | Ø8 | Ø8 |
| 47Ø | 85 | + |
| 471 | Ø3 | 3 |

| | | |
|---|---|---|
| 472 | 06 | 6 |
| 473 | 05 | 5 |
| 474 | 75 | - |
| 475 | 43 | RCL |
| 476 | 09 | 09 |
| 477 | 54 | ) |
| 478 | 29 | CP |
| 479 | 22 | INV |
| 480 | 77 | GE |
| 481 | 97 | DSZ |
| 482 | 54 | ) |
| 483 | 61 | GTO |
| 484 | 90 | LST |
| 485 | 76 | LBL |
| 486 | 95 | = |
| 487 | 01 | 1 |
| 488 | 00 | 0 |
| 489 | 00 | 0 |
| 490 | 00 | 0 |
| 491 | 49 | PRD |
| 492 | 08 | 08 |
| 493 | 49 | PRD |
| 494 | 09 | 09 |
| 495 | 53 | ( |
| 496 | 53 | ( |
| 497 | 43 | RCL |
| 498 | 08 | 08 |
| 499 | 75 | - |
| 500 | 43 | RCL |
| 501 | 09 | 09 |
| 502 | 54 | ) |
| 503 | 29 | CP |
| 504 | 22 | INV |
| 505 | 77 | GE |
| 506 | 97 | DSZ |
| 507 | 54 | ) |
| 508 | 76 | LBL |
| 509 | 90 | LST |
| 510 | 42 | STO |
| 511 | 12 | 12 |
| 512 | 69 | OP |
| 513 | 05 | 05 |
| 514 | 53 | ( |
| 515 | 93 | . |
| 516 | 09 | 9 |
| 517 | 65 | X |
| 518 | 43 | RCL |
| 519 | 15 | 15 |
| 520 | 85 | + |
| 521 | 93 | . |
| 522 | 01 | 1 |
| 523 | 65 | X |
| 524 | 43 | RCL |
| 525 | 12 | 12 |

| | | |
|---|---|---|
| 526 | 54 | ) |
| 527 | 42 | STO |
| 528 | Ø6 | Ø6 |
| 529 | 58 | FIX |
| 53Ø | ØØ | ØØ |
| 531 | 99 | PRT |
| 532 | 22 | INV |
| 533 | 58 | FIX |
| 534 | 98 | ADV |
| 535 | Ø3 | 3 |
| 536 | ØØ | Ø |
| 537 | Ø1 | 1 |
| 538 | Ø3 | 3 |
| 539 | Ø1 | 1 |
| 54Ø | Ø6 | 6 |
| 541 | ØØ | Ø |
| 542 | ØØ | Ø |
| 543 | 69 | OP |
| 544 | Ø3 | Ø3 |
| 545 | 69 | OP |
| 546 | Ø5 | Ø5 |
| 547 | 53 | ( |
| 548 | 53 | ( |
| 549 | 43 | RCL |
| 55Ø | 12 | 12 |
| 551 | 75 | − |
| 552 | 43 | RCL |
| 553 | 15 | 15 |
| 554 | 54 | ) |
| 555 | 5Ø | \|X\| |
| 556 | 65 | X |
| 557 | 93 | . |
| 558 | Ø1 | 1 |
| 559 | 85 | + |
| 56Ø | 43 | RCL |
| 561 | 16 | 16 |
| 562 | 65 | X |
| 563 | 93 | . |
| 564 | Ø9 | 9 |
| 565 | 54 | ) |
| 566 | 42 | STO |
| 567 | Ø7 | Ø7 |
| 568 | 58 | FIX |
| 569 | ØØ | ØØ |
| 57Ø | 99 | PRT |
| 571 | 22 | INV |
| 572 | 58 | FIX |
| 573 | 98 | ADV |
| 574 | 43 | RCL |
| 575 | Ø6 | Ø6 |
| 576 | 42 | STO |
| 577 | 15 | 15 |
| 578 | 43 | RCL |
| 579 | Ø7 | Ø7 |

| | | |
|---|---|---|
| 58Ø | 42 | STO |
| 581 | 16 | 16 |
| 582 | 61 | GTO |
| 583 | 99 | PRT |
| 584 | 76 | LBL |
| 585 | 13 | C |
| 586 | Ø3 | 3 |
| 587 | Ø4 | 4 |
| 588 | 69 | OP |
| 589 | Ø4 | Ø4 |
| 59Ø | 53 | ( |
| 591 | 53 | ( |
| 592 | Ø8 | 8 |
| 593 | 65 | X |
| 594 | Ø5 | 5 |
| 595 | ØØ | Ø |
| 596 | 65 | X |
| 597 | 43 | RCL |
| 598 | 17 | 17 |
| 599 | 54 | ) |
| 6ØØ | 55 | -:- |
| 6Ø1 | 53 | ( |
| 6Ø2 | 93 | . |
| 6Ø3 | Ø2 | 2 |
| 6Ø4 | 65 | X |
| 6Ø5 | 43 | RCL |
| 6Ø6 | 1Ø | 1Ø |
| 6Ø7 | 54 | ) |
| 6Ø8 | 54 | ) |
| 6Ø9 | 34 | SQRT |
| 61Ø | 58 | FIX |
| 611 | ØØ | ØØ |
| 312 | 69 | OP |
| 613 | Ø6 | Ø6 |
| 614 | 22 | INV |
| 615 | 58 | FIX |
| 616 | 98 | ADV |
| 617 | Ø3 | 3 |
| 618 | Ø6 | 6 |
| 619 | 69 | OP |
| 62Ø | Ø4 | Ø4 |
| 621 | 53 | ( |
| 622 | 53 | ( |
| 623 | 53 | ( |
| 624 | 43 | RCL |
| 625 | 15 | 15 |
| 626 | 55 | -:- |
| 627 | Ø9 | 9 |
| 628 | Ø1 | 1 |
| 629 | 65 | X |
| 63Ø | Ø1 | 1 |
| 631 | 93 | . |
| 632 | Ø5 | 5 |
| 633 | Ø7 | 7 |

| | | |
|---|---|---|
| 634 | 65 | X |
| 635 | 43 | RCL |
| 636 | 18 | 18 |
| 637 | 54 | ) |
| 638 | 85 | + |
| 639 | 53 | ( |
| 64Ø | 43 | RCL |
| 641 | 17 | 17 |
| 642 | 33 | X**2 |
| 643 | 65 | X |
| 644 | Ø1 | 1 |
| 645 | 93 | . |
| 646 | Ø5 | 5 |
| 647 | Ø7 | 7 |
| 648 | 65 | X |
| 649 | 43 | RCL |
| 65Ø | 16 | 16 |
| 651 | 55 | -:- |
| 652 | Ø9 | 9 |
| 653 | Ø1 | 1 |
| 654 | 54 | ) |
| 655 | 54 | ) |
| 656 | 34 | SQRT |
| 657 | 65 | X |
| 658 | Ø1 | 1 |
| 659 | 93 | . |
| 66Ø | Ø2 | 2 |
| 661 | Ø8 | 8 |
| 662 | Ø1 | 1 |
| 663 | Ø5 | 5 |
| 664 | 85 | + |
| 665 | 43 | RCL |
| 666 | 17 | 17 |
| 667 | 65 | X |
| 668 | 43 | RCL |
| 669 | 15 | 15 |
| 67Ø | 55 | -:- |
| 671 | Ø9 | 9 |
| 672 | Ø1 | 1 |
| 673 | 54 | ) |
| 674 | 58 | FIX |
| 675 | ØØ | ØØ |
| 676 | 69 | OP |
| 677 | Ø6 | Ø6 |
| 678 | 98 | ADV |
| 679 | 22 | INV |
| 68Ø | 58 | FIX |
| 681 | 92 | RTN |
| 682 | 76 | LBL |
| 683 | 97 | DSZ |
| 684 | 69 | OP |
| 685 | ØØ | ØØ |
| 686 | Ø1 | 1 |
| 687 | Ø4 | 4 |

| | | |
|---|---|---|
| 688 | 01 | 1 |
| 689 | 03 | 3 |
| 690 | 01 | 1 |
| 691 | 06 | 6 |
| 692 | 00 | 0 |
| 693 | 00 | 0 |
| 694 | 69 | OP |
| 695 | 03 | 03 |
| 696 | 02 | 2 |
| 697 | 04 | 4 |
| 698 | 03 | 3 |
| 699 | 01 | 1 |
| 700 | 03 | 3 |
| 701 | 03 | 3 |
| 702 | 04 | 4 |
| 703 | 01 | 1 |
| 704 | 03 | 3 |
| 705 | 07 | 7 |
| 706 | 69 | OP |
| 707 | 04 | 04 |
| 708 | 69 | OP |
| 709 | 05 | 05 |
| 710 | 61 | GTO |
| 711 | 99 | PRT |

To modify the above program to constrain the order quantity to be no more than 30 days of average demand, the following instructions would be inserted between instructions 609 and 610. The rest of the program remains unchanged.

| | | |
|---|---|---|
| 610 | 32 | X<>T |
| 611 | 53 | ( |
| 612 | 43 | RCL |
| 613 | 17 | 17 |
| 614 | 55 | -:- |
| 615 | 03 | 3 |
| 616 | 54 | ) |
| 617 | 22 | INV |
| 618 | 77 | GE |
| 619 | 37 | P/R |
| 620 | 32 | X<>T |
| 621 | 76 | LBL |
| 622 | 37 | P/R |

APPENDIX: C

A Sample Update Calculation

Assume the following information:

| | | | |
|---|---|---|---|
| Smoothed mean demand | 300 | Ordering Cost | $50 |
| Smoothed MAD of demand | 20 | Holding Cost | .2 |
| Smoothed mean lead time | 21 | Service level | 90% |
| Smoothed MAD of lead time | 7 | | |
| Observed demand | 200 | Unit cost | $ 2 |
| Julian date ordered | 0160 | | |
| Julian date received | 0175 | | |

To update the stock record using the TI-59 program from Appendix B, press key A. Prompting messages will be printed to request data. After the data is entered, press the R/S key to resume program execution.

| PROMPTING MESSAGE | DATA ENTRY |
|---|---|
| ENTER COST | 2 |
| ENTER OBS DMD | 200 |
| ENTER OLD MEAN DMD | 300 |
| ENTER OLD MAD DMD | 20 |

The program will then calculate and print:

| | |
|---|---|
| NEW MEAN DMD | 290 |
| NEW MAD DMD | 28 |

Then the following prompting messages will be printed:

| PROMPTING MESSAGE | DATA ENTRY |
|---|---|
| ENTER OLD MEAN LTIME | 21 |
| ENTER OLD MAD LTIME | 7 |

PRESS B TO CAL LTIME
PRESS C TO CAL Q + S

Since an order was processed during the current quarter, press key B. The following messages will be printed:

| PROMPTING MESSAGE | DATA ENTRY |
|---|---|
| ENTER DATE ORD | 0160 |
| ENTER DATE REC | 0175 |

The program will then compute and print:

```
NEW MEAN LTIME                       20
NEW MAD  LTIME                        7

PRESS B TO CAL LTIME
PRESS C TO CAL Q + S
```

If more than one order had been processed during the quarter, key B would be pressed and the lead time calculations would be repeated. After all orders have been entered, the last values calculated for lead time are used to update the stock record. Then press key C and the program will calculate and print:

```
ORDER QUANTITY                      539
REORDER POINT                       193
```

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